L-3 Review – inertia

- Inertia ➜ the tendency of objects to resist changes in motion.
  - If an object is at rest, it stays at rest.
  - If an object is moving with constant velocity, it continues moving with constant velocity unless something stops it.
- The inertia of an object is measured by its mass in kilograms (kg) – the quantity of matter in it.

Forces can change velocity!

- ➜ No force is required to keep an object moving with constant velocity.
- What can change the velocity of an object? ➜ FORCES
  - acceleration is a change in velocity
  - forces produce accelerations
  - for example: friction or air resistance

The force of gravity

- Today we will explore one force that can change the velocity of an object
  ➜ GRAVITY
  - Everything that has mass is affected by gravity
  - It is the most common force we have to deal with – it’s what keeps us on earth and the Earth revolving around the Sun.

Weight and gravity

- All objects exert an attractive force on each other – Universal Law of Gravity
  - Your weight is the attractive force that the earth exerts on you – it’s what makes things fall!
  - All objects are pulled toward the center of the earth by gravity.
  - The sun’s gravity is what holds the solar system together.
  - It is a non-contact force ➜ no touching required!

Newton’s Law of Gravity

- The force of gravity depends on how large the masses are ➜ big M’s ➜ big force
- How far apart they are, the closer the masses are ➜ the bigger the force
- Since we are closer to the Earth than to the Sun, our gravitational force is mainly due to the Earth

The sun is the most massive object in the solar system, about 3 million times the earth’s mass and 1000 times more massive than the most massive planet-Jupiter

Astronomers have recently reclassified PLUTO as a dwarf planet.
Pluto discovered in 1930 by Clyde Tombaugh of Streator, IL
A little Astronomy

• The planets revolve around the sun in approximately circular paths (Kepler)
• The further the planet is from the sun the longer it takes to go around (Kepler)
• The time to go around the sun is a year – the earth spins on its axis once every day – the moon revolves around the earth once every month.

What does your weight depend on?

• The weight \( w \) of an object depends on its mass and the local strength of gravity - we call this \( g \) - the acceleration due to gravity.
• Weight points toward the earth’s center.
• Sometimes down is up!

What is this thing called \( g \)?

• \( g \) is something you often hear about, for example
• You might hear that a fighter pilot experienced so many \( g \)’s when turning his jet plane.
• \( g \) is the acceleration due to gravity.
• When an object falls its speed increases as it descends.
• Acceleration is the rate of change of velocity.
• \( g \) is the amount by which the speed of a falling object increases each second – about 10 meters per second each second (9.8 m/s/s = 9.8 m/s\(^2\), to be exact).

Example – a falling object

<table>
<thead>
<tr>
<th>time (s)</th>
<th>velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
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<tr>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
</tr>
</tbody>
</table>

Change in velocity, or acceleration = 10 m/s/s, or, 10 m/s\(^2\).

How to calculate weight

• Weight = mass x acceleration due to gravity.
• Or \( w = m \times g \) (mass times \( g \)).

In this formula \( m \) is given in kilograms (kg), and \( g \approx 10 \) meters per second per second (m/s\(^2\)), then \( w \) comes out in force units – Newtons (N).

\( \approx \) Means approximately equal to.
example

Question: What is the weight of a 100 kg object?

Answer: \( w = m \times g = 100 \text{ kg} \times 10 \text{ m/s}^2 = 1000 \text{ N} \)

- One Newton is equal to 0.225 pounds (lb), so in these common units 1000 N = 225 lb
- Often weights are given by the equivalent mass in kilograms, we would say that a 225 lb man "weighs" 100 kg; this is commonly done but, strictly speaking, is not correct.

You weigh more on Jupiter and less on the moon

- The value of \( g \) depends on where you are, since it depends on the mass of the planet
- On the moon \( g \approx 1.6 \text{ m/s}^2 \approx \frac{1}{6} \text{ g on earth} \), so your weight on the moon is only \( \frac{1}{6} \) your weight on earth (video)
- On Jupiter, \( g \approx 23 \text{ m/s}^2 \approx 2.3 \text{ g on earth} \), so on Jupiter you weigh 2.3 times what you weigh on earth
- Your mass is the same everywhere!

Get on the scale:
How to weigh yourself

Free Fall

- Galileo showed that all objects (regardless of mass) fall to earth with the same acceleration \( \rightarrow g = 10 \text{ m/s}^2 \)
- This is only true if we remove the effects of air resistance. demos
- We can show this by dropping two very different objects inside a chamber that has the air removed.

Galileo’s experiments

- To test this we must drop two objects from the same height and measure the time they take to fall.
- If \( H \) isn’t too big, then the effects of air resistance are minimized

On the other hand . . .

- If you drop an object from a small height it falls so quickly that it is difficult to make an accurate measurement of the time
- We can show experimentally that it takes less than half a second for a mass to fall 1 meter. (demo)
- How did Galileo deal with this?
What did Galileo learn from his inclined plane experiments?

• He measured the time it took for different masses to fall down the inclined plane.
• He found that different masses take the same time to fall down the inclined plane.
• Since they all fall the same distance, he concluded that their accelerations must also be the same.
• By using different distances he was able to discover the relation between time and distance.
• How did Galileo deal with friction?

How did Galileo measure the time?

• Galileo either used his own pulse as a clock (he was trained to be a physician)

• Or, a pendulum.

Galileo made g smaller!

\[ g_{\text{straight down}} = 10 \text{ m/s}^2 \]

\[ g_{\text{down ramp}} = g_{\text{straight down}} \times \frac{h}{D} \]

Can be made small by using a small h or big D

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